# The ecology and economics of autumn leaves

October 11 2016, by Jeff Atkins

Beyond pumpkin flavored everything, autumn is big business in some parts of the United States. And the main draw are the leaves themselves. In New England alone, tourists venturing to witness the change-in-color, a hobby known colloquially as "leaf peeping," spend upwards of $3 billion US dollars annually. There are even great debates about where the best places to go "leaf peeping" are—a personal nod for me towards the Great Smoky Mountains in North Carolina and the Canaan Valley in West Virginia. And while we are amazed at the natural tapestry autumn brings us, the underlying ecology is equally fascinating.

First, it is important to understand why (most) leaves are green in the first place. The answer lies with chlorophyll—a pigment found in cyanobacteria and chloroplasts (the organs in a leaf where photosynthesis occurs). Chlorophyll allows plants to absorb energy from light. Chlorophyll absorbs light in the blue and red portions of the electromagnetic spectrum most strongly, while poorly absorbing light in the green portion—meaning that it is going to appear green as this is the light chlorophyll most readily reflects.

If we think of plants as carbon-fixing, sugar-producing machines, the question arises of why then are leaves not black? Black leaves would absorb all of the available light energy and allow maximum efficiency for a plant, right? In fact, the peak strength of solar radiation available to plants appears in the visible green portion of the magnetic spectrum (495-570 nanometers). Wouldn't any other color but green be optimal?

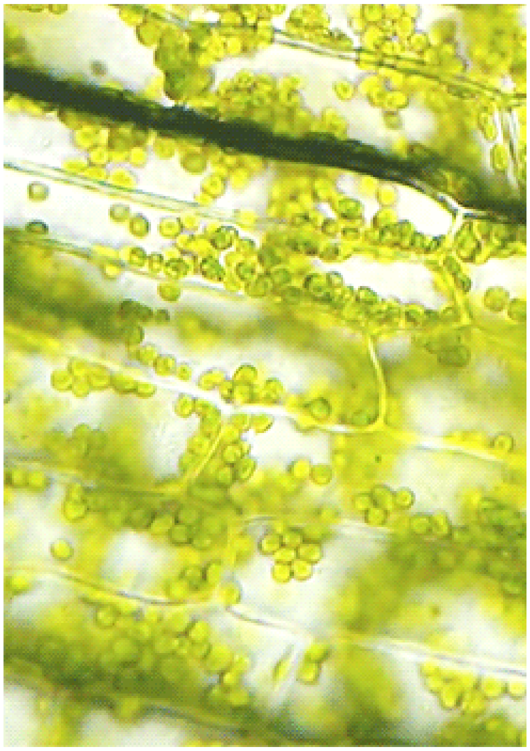
A plant in full sunlight is likely working with more available energy than it can possibly use. Photosynthesis relies on more than chlorophyll located in the chloroplasts. A plant has to have available water in order to fix carbon through photosynthesis and also has to be within a certain temperature range. Enzymes within the leaves will not work at low or high temperatures. Water exits and carbon dioxide enters a leaf through the leaf's stoma—tiny pores on the surface of the leaf. When the stoma are open, carbon dioxide can enter the plant and photosynthesis can occur. However, the plant has to lose water to gain that carbon dioxide. If a plant loses too much water, then it's toast. The plant in turn regulates this process by opening and closing the stoma. There is a trade-off between how much photosynthesis a plant can perform without over-exerting itself.

Sugar maples beginning to change color in Petersham, MA (October, 4, 2016). Credit: Neil Pederson

So why green?

Remember how I mentioned that solar radiation is at its peak energy in the green portion of the spectrum? High light intensity can retard photosynthesis in a couple of ways. First it heats the leaves up, affecting the enzymes that catalyze photosynthesis. A warm leaf also has to pump through more water to get more carbon dioxide, affecting water loss. Think of running on a really, really hot day. Now imagine doing that while wearing all black.

In fact, it would be counterproductive for plants and leaves in many areas of the world to be any other color than green. The absorbed energy from being a different color would be way beyond what the plant is able to use and would be detrimental to the plant. However, there is interesting spatial variation in leaf color due to many factors.

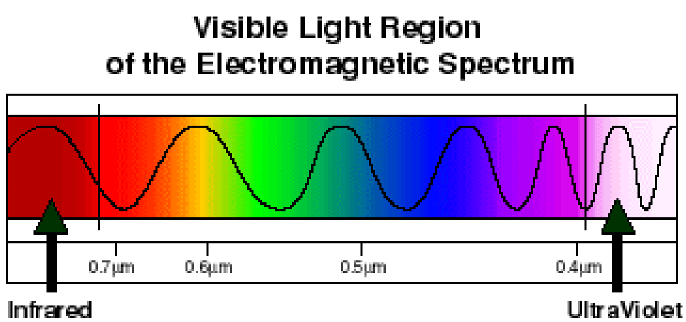


Chloroplasts inside of the leaf moving in response to light.

First, what we think of as "green" is actually chlorophyll-a, the most abundant pigment on earth and the primary chlorophyll in terrestrial plants. There is also chlorophyll-b, a second pigment with a slightly different absorbance profile, that is less abundant and likely evolved later than chlorophyll-a.

Beyond chlorophyll, there are other pigments located in plants. Plants also contain carotenoids—pigments that can be orange, yellow, or red in color. Remember the carotene in carrots that makes them orange? The primary role of these pigments, seems to be in protecting plants from free radicals that can form from exposure to ultra-violet radiation. These pigments may also contribute to photosynthesis by secondary transfer of absorbed energy to chloroplasts, but primarily aid photosynthesis through dissipating excess energy. Without carotenoids, excess light energy could result in the destruction of membranes and proteins in the leaf.

During the summer and spring, while the days are nice and long, leaves are photosynthesizing and happily growing. As the days shorten and the nights get longer as autumn comes, an abscission layer begins to form at the base of where the leaf connects to the branch. It is interesting that the genesis of the layer is most strongly correlated with day length, rather than temperature resulting in color-change being fairly predictable from year-to-year (check out this really cool interactive).

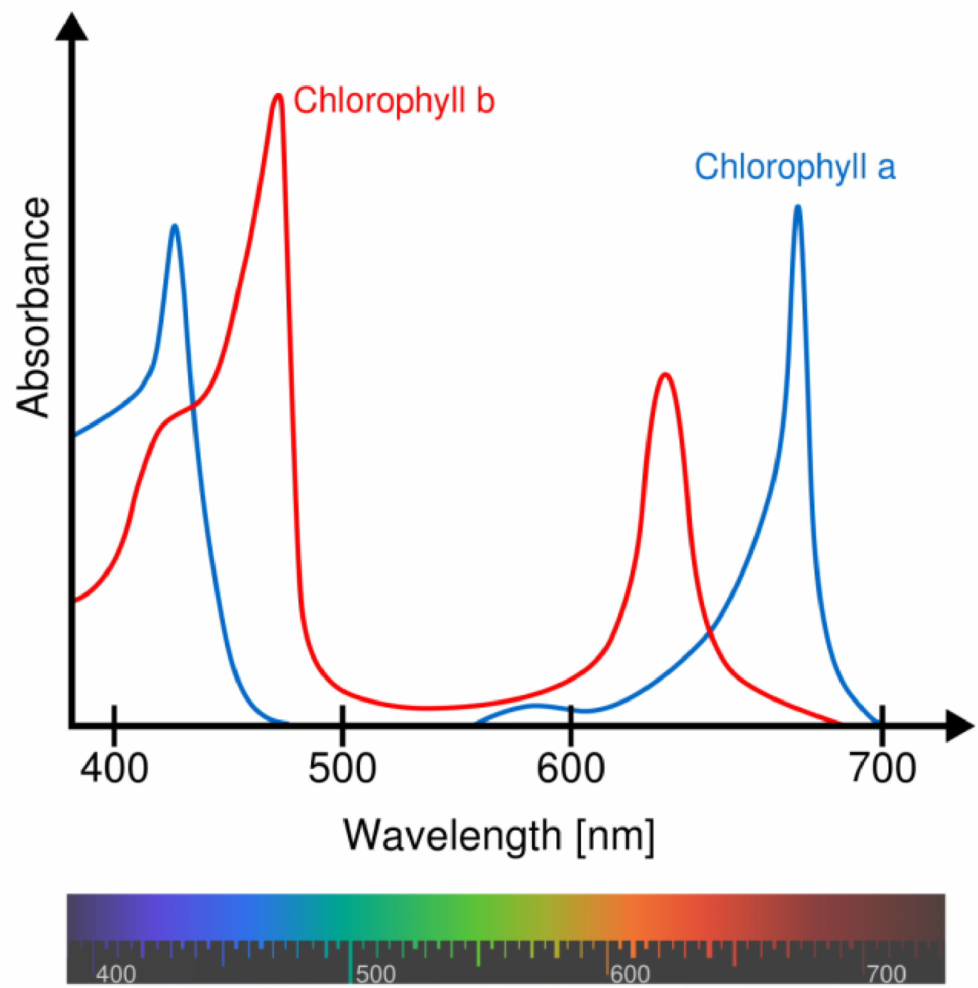



This "corky" abscission layer prevents the transport of nutrients, minerals, and water to the leaf. Chlorophyll constantly must be produced and replaced within a leaf. When this abscission layer begins to form, the production of chlorophyll stops. Without chlorophyll, the leaf begins to change in color. It's not so much that the leaf is turning another color, but rather losing its green. All of the carotenoids and other minor pigments such as flavonoids and anthocyanins become visibly apparent. This is where we get those reds, oranges, yellows, and purples. Eventually the abscission layer becomes complete and the leaf will detach from the tree and fall to the ground.

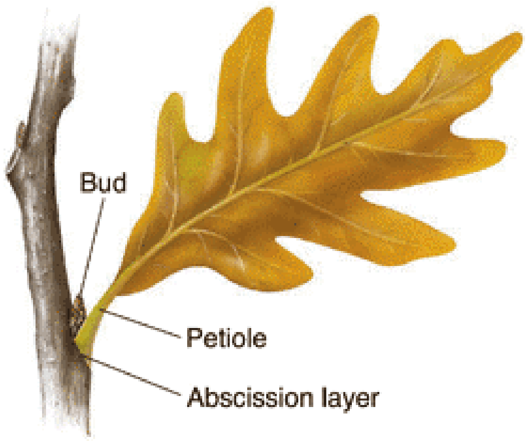
There is the question of how fall foliage will be affected by anthropogenic climate change. Remember that $3 billion dollar economic estimate for the northeast alone? That's a huge financial impact for such a small region. While day length is a primary cue for plant phenology, temperature acts as a strong secondary control. There are also necessary considerations of how increased rainfall and cloud cover, prolonged droughts, and changing humidity, along with other anthropogenic driven ecological impacts such as acidic deposition, air pollution, and land-use change will impact these forests and ecosystems. This may prove to be an important research avenue moving forward.

In the meantime, get outside and get to leaf peeping. Or watch from your computer thanks to people like the National Phenology Network and Earthcam.

Leaves are incredibly responsive to their environment and change angle during the day depending on light intensity. During periods of high light intensity, you may see leaves wilt as the angle themselves away from the sun, limiting direct exposure.




Chlorophyll-a and -b absorb energy at slightly different points on the electromagnetic spectrum, allowing for a plant to better optimize light absorbance.




*This story is republished courtesy of PLOS Blogs:* [blogs.plos.org](blogs.plos.org).

Provided by Public Library of Science

Citation: The ecology and economics of autumn leaves (2016, October 11) retrieved 25 April 2024 from https://phys.org/news/2016-10-ecology-economics-autumn.html